Ministry of Forests, 518 Lake Street, Nelson, British Columbia V1L 4C6

Wildlife Trees and Their Use by Cavity Nesters in Selected Stands of the Nelson Forest Region

Christoph Steeger and Marlene M. Machmer
PANDION ECOLOGICAL RESEARCH LTD.
P.O. Box 26, Ymir, B.C. V0G 2K0

Technical Report TR-010

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ABSTRACT

In 1992, a wildlife tree research project was initiated in the Nelson Forest Region to examine the wildlife tree habitat and its use by cavity-nesting wildlife species in mature stands of the Interior Cedar-Hemlock biogeoclimatic zone. The long-term goal of this project is to determine which silvicultural systems are best suited for the maintenance of wildlife tree-dependent species and to develop management guidelines for retention of wildlife trees during harvest. This report summarizes the results from the first three years of this project.

At the study sites, wildlife trees accounted for approximately one-third of all trees sampled and approximately one-quarter of all trees sampled were dead. Densities of wildlife trees ranged from 110 to 148 stems per hectare and two-thirds of all wildlife trees sampled showed evidence of current or past use by cavity nesters. In general, the majority of wildlife trees used by cavity nesters were snags of large diameter (> 40 cm dbh) and a minimum of 15-20 m in height. Many of these trees were infected with Armillaria root disease and heart rots and showed signs of bark or wood-boring beetle attack. The density of active nests located in 1995 on proposed cutblocks in the Deer Creek landscape unit, Arrow Forest District, was 0.70 nests per hectare. Implications of summer logging operations and forest health management activities for wildlife tree-dependent species are discussed, and management recommendations for wildlife tree retention in the Nelson Forest Region are put forward.

ACKNOWLEDGEMENTS

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1 INTRODUCTION

There is life in dead and dying trees! This realization has prompted the province of British Columbia to develop a wildlife tree management program in order to stop the current systematic removal of wildlife trees from natural forests. The primary goal of this initiative is to ensure the conservation of dead, defective, and dying trees and of the wildlife species dependent on such trees within managed forests.

The B.C. Wildlife Tree Committee (1995) defines a wildlife tree as any "standing dead or live tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife". More than 90 wildlife species, or approximately 16% of the province's native vertebrates, depend on wildlife tree habitat for many of their life functions including reproduction, feeding, shelter, and communication.

The largest group of wildlife tree users is that of cavity-nesting birds. These include primary cavity excavators (such as woodpeckers, nuthatches and chickadees) and secondary cavity users (such as small ducks, owls, raptors and Brown Creepers[1]). Wildlife tree-dependent mammals include most bats, some forest rodents and furbearers, and bears and caribou. Two species of salamander are also considered wildlife tree-dependent.

Many wildlife tree users play important ecological roles in forest ecosystems (Machmer and Steeger 1995). Most notable is the significant impact that some of these species have on the abundance and distribution of forest pest insects. This effect has been particularly well-documented in bark-foragers (e.g., woodpeckers, nuthatches) and foliage-gleaning birds (e.g., chickadees). Members of these groups directly influence insect pest abundance by consuming large numbers of prey (such as bark beetles, budworms, tussock moths, and sawflies) and by modifying their foraging and reproductive behaviour in response to changes in prey density. Primary cavity excavators, for their part, provide other cavity-dependent species (e.g., secondary cavity-using birds, bats, rodents, and mustelids) with feeding, roosting, and nesting sites (Backhouse and Lousier 1991). They are also thought to play significant roles in seed dispersal, accelerating the rate of decomposition in dead and decaying trees, nutrient cycling, and the transmission of insect and tree pathogens (Otvos 1979; Machmer and Steeger 1995).

[1] Scientific names of species appear in Appendix 1.

As well as their importance to vertebrate species, wildlife trees provide essential habitat for other groups of organisms, including invertebrates, lichen, and fungi. Once fallen, the trees become "coarse woody debris" habitat for species that inhabit the forest floor. Ultimately, wildlife trees become an important component of nutrient cycles.

Despite its important ecological role, British Columbia's wildlife tree resource is rapidly declining as a result of conventional silviculture systems, fire prevention practices, timber utilization standards, firewood cutting, and worker safety regulations. This decline seriously threatens the viability of many wildlife populations, to the extent that entire species may become endangered. In response to this forest management problem, several provincial and regional initiatives are currently under way to ensure the conservation of wildlife tree habitat:

- The Forest Practices Code *Biodiversity Guidebook* calls for the consideration of wildlife tree habitat (B.C. Ministry of Forests 1995).
- A Wildlife/Danger Tree Assessor's Course is now being offered through the B.C. Forestry Continuing Studies Network.
- Regional and district wildlife tree management guidelines are being prepared (e.g., Lindsey 1992, Coates and Stevenson 1994).
- Several field research projects are under way.

One of the latter, a wildlife tree field study, was initiated in the spring of 1992 in the Interior Cedar-Hemlock (ICH) biogeoclimatic zone of the Nelson Forest Region. This five-year project - the third-year results of which are summarized in this report - is aimed at determining the functions of wildlife trees within interior forest ecosystems and at providing the necessary background information for effective wildlife tree management.

Specifically, its objectives are to:

- describe the existing wildlife tree habitat and its functional significance for cavity-nesting birds and mammals;
- examine the effects of a modified silviculture system (clearcut with wildlife tree patches) on cavity-nesting birds and mammals; and
- develop criteria and guidelines for wildlife tree management in interior forest ecosystems.

In 1992, fieldwork was conducted within the ICHdw and ICHmw2 subzones of the West Arm Demonstration Forest, Kootenay Lake Forest District. Preliminary results from the 1992 season are presented in Steeger et al. (1993). Because of constraints to the planned harvesting trials in the demonstration forest, however, a second research site was adopted in 1993. The second site is in the ICHdw subzone of the Deer Creek landscape unit, Arrow Forest District, and is scheduled to be harvested during winter 1995/96.

2 STUDY AREA

2.1 West Arm Demonstration Forest

The demonstration forest is located north of the West Arm of Kootenay Lake near the city of Nelson, B.C. (Figure 1). The four subzones/variants recognized along the elevational gradient from the lake shore to the subalpine are ICHdw, ICHmw2, ESSFwc1, and ESSFwc4, respectively. These ecosystem units are described in detail in Braumandl and Curran (1992). The forests in the area were burned extensively about 90 years ago; hence, the old-growth component within these stands is minor. In the ICH, climax species of western redcedar and western hemlock are restricted mainly to riparian zones. Field work was concentrated within mature stands of the Busk Creek and Redfish Creek drainages. The Busk Creek site consists mainly of mature Douglas-fir, with a component of large veteran ponderosa pine; the Redfish Creek site consists almost entirely of Douglas-fir. Study site parameters are given in Table 1.

2.2 Deer Creek Landscape Unit

The Deer Creek field site is located at Cougar Ridge north of Lower Arrow Lake (Figure 1). It lies within the ICHdw subzone (Braumandl and Curran 1992) and is generally southwest facing, with either flat or low to moderate slope. Dominant conifer species are Douglas-fir (50%), lodgepole pine (25%), and western larch (15%), with a minor component of localized western redcedar, western hemlock, and ponderosa pine. The hardwood component (4%) is dominated by trembling aspen and paper birch. Most of the stand is mature second growth (age 85-95), with patches of young seral lodgepole pine. (See site parameters in Table 1.)

About 30 years ago, the stand was selectively logged for large western redcedar, western hemlock, and Douglas-fir. The natural disturbance history of the area is characterized by a

major fire in 1942, a minor ground fire in 1968, mountain pine beetle (*Dendroctonus ponderosae*) at endemic levels, and widespread occurrence of Armillaria root disease (*Armillaria ostoyae*) and larch dwarf mistletoe (*Arceuthobium laricis*).

TABLE 1. Study site parameters

	Study site		
Site parameters	Busk Creek	Redfish Creek	Deer Creek
Total area (ha)	30	30	52
BEC[1] subzone	ICHdw	ICHdw/mw2	ICHdw
Site series	01a, 01b	ICHdw: 01, 04 ICHmw2: 03, 04	01a, 01b, 02, 03, 04
Aspect	south	south	south to west
Average slope (%)	55	63	22
Slope position	lower slope	middle slope	level to lower slope
Elevation (m)	980-1250	1160-1400	820-1000

[1] BEC = Biogeoclimatic Ecosystem Classification (Pojar et al. 1987)

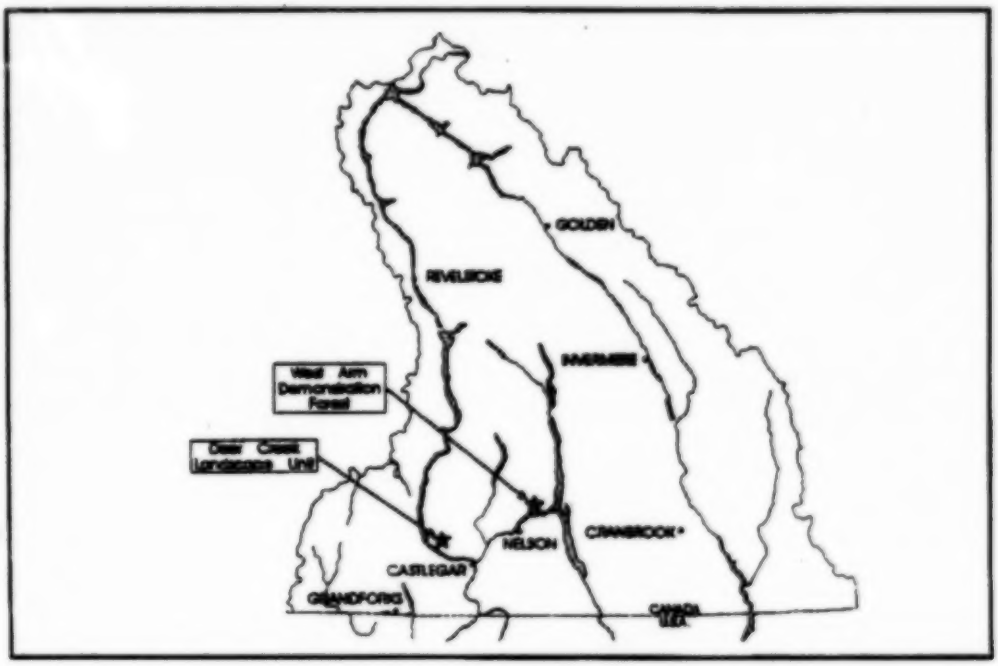

FIGURE 1. Locations of study sites

3 METHODS

3.1 Wildlife Tree Surveys

To determine the density, proportion (number of wildlife trees/total number of trees), characteristics, distribution, and use of wildlife trees at the study sites, trees were assessed on 0.04 ha circular plots (11.28 m radius). Plots were systematically located on a 100 x 100 m grid for a total of one plot per hectare. Because the Deer Creek site had been surveyed before this study in preparation for silviculture prescriptions, we superimposed wildlife tree sampling plots on existing cruise plots.

For the purpose of this study, a wildlife tree is defined as (1) either coniferous or deciduous, (2) greater than 10 cm diameter at breast height (dbh), and (3) of decay class 1-7 (B.C. Wildlife Tree Committee 1993). Decay classes are defined as follows:

1 = live, healthy trees used for either nesting or foraging by woodpeckers. Note that in this study only woodpecker sign is considered as a criterion for class 1 designation because these birds leave quantifiable foraging sign, are highly dependent on wood-boring insects, and are the only primary cavity nesters that may breed in generally healthy trees;

2 = live but defective tree; characterized, for example, by broken top or trunk, dead limbs, internal decay, or insect or fire damage;

3 = standing dead tree (snag) that has died recently; characterized by hard stemwood, an intact trunk, and most or all branches and twigs present;

4 = hard snag with at least 50% of branches and twigs absent, some loose bark, and top usually broken;

5 = spongy snag with internal decay; characterized by spongy heartwood, most branches and bark absent, and usually a broken top or trunk;

6 = soft snag with internal decay that has progressed to soften the heartwood, characterized by sapwood/heartwood sloughing from upper bole and a broken trunk;

7 = soft snag with extensive internal decay and exterior deterioration.

During this study, trees in decay classes 8 (soft stumps) and 9 (debris) (B.C. Wildlife Tree Committee 1993) were scarce and indistinct. They were therefore omitted during data collection.

The following variables were measured within each plot:

- total number, species, dbh (cm), height (m), and decay class of wildlife trees,
- total number, species, and dbh of all live (non-wildlife) trees greater than 10 cm,
- number of nesting cavities and feeding excavations per wildlife tree, and
- presence of broken tops or trunks and disturbance and mortality agents (Deer Creek site only).

3.2 Wildlife Species Surveys

Cavity-nesting birds and mammals (e.g., woodpeckers, chickadees, nuthatches, and squirrels) were chosen as the focal group of species for this investigation because (1) they are highly dependent on wildlife trees, (2) individuals are relatively easy to detect and follow, (3) they are territorial, year-round residents, and (4) individual cavity-nesters (e.g., Pileated Woodpeckers) are often considered to be ecological indicator species. The indicator species concept assumes that by meeting the habitat requirements of, for example, woodpeckers, the requirements of other species are met too. While this approach may not be applicable to the management of particular species, it is useful for wildlife diversity management and as a starting point for investigating the habitat needs of forest wildlife species.

Study sites were systematically searched along transect lines for the presence of cavity nesters and trees with active cavity nests. Nest occupancy was confirmed either by observing a cavity until a bird or mammal appeared at the nest, or by following birds to their nests. Once a nest tree was located, bird or mammal species, tree species, dbh, height, and decay class, height of nest cavity, and tree disturbance agents (if applicable) were determined. To assess the characteristics of the habitat surrounding nest trees, 0.04 ha circular sampling plots were established, centred at the nest tree. The following variables were measured within each nest plot: site series, slope, aspect, and number of stems (>10 cm dbh) of live conifers, live deciduous hardwoods, and snags.

To document the role of wildlife trees as foraging substrate, woodpecker foraging sign was evaluated. Within each 0.04 ha sampling plot, the number of wildlife trees with evidence of foraging excavations were counted. (It should be noted that this method of quantifying

foraging use is very conservative: insects gleaned off the bark surface or from the foliage are also taken by cavity nesters, but the latter foraging methods do not leave visible sign and were therefore not measured.) In 1994, focal observations on foraging woodpeckers were conducted at the Deer Creek site. The dbh, decay stage, and disturbance agents were recorded for each tree that woodpeckers were observed using.

To determine current use of wildlife trees by cavity nesters, old and new nest cavities and feeding excavations were quantified separately. New nest cavities are characterized by fresh scrapings or chippings around the lower edge of the entrance hole; recently excavated foraging holes are characterized by their coloration, with old excavations being bleached gray.

3.3 Disease and Insect Surveys

Disease agents and pest insects were assessed to determine the mortality and disturbance agents involved in creating wildlife trees. At Deer Creek (1993), wildlife trees were visually assessed for the presence or absence of Armillaria root disease on the basis of above-ground symptoms (e.g., thin chlorotic foliage, resinosis, and exposed mycelial fans). This method of estimating the number of Armillaria-infected trees per plot is conservative (B.C. Ministry of Forests 1995). In 1994, surveys of tree disturbance agents were expanded to include root disease, stem rot (on the basis of visible conks), mistletoe (on the basis of visible brooms), and bark beetles.

No systematic sampling of mortality and disturbance agents on wildlife tree plots was conducted at Busk and Redfish creeks in 1992.

3.4 Analysis

The data summarized in this report were collected during the pre-harvest surveys of the treatment blocks and control sites. Hence, only descriptive statistics are presented here. The differences in diameter between used and unused live healthy trees were analyzed using the t-test method (Sokal and Rohlf 1981). The density of wildlife trees per hectare was extrapolated from the number of wildlife trees per 0.04 ha sampling plot.

4 RESULTS

4.1 Proportions of Wildlife Trees

The proportion of all trees that, by definition, should be considered as wildlife tree habitat, is presented in Figure 2. Approximately one-third of all trees within the selected stands are wildlife trees and about one-quarter are dead. The difference between the values for all wildlife trees and dead wildlife trees within a site (Busk = 0.07, Redfish = 0.09, Deer = 0.02) indicates the proportion of used and/or defective live trees within a given stand and provides a rough estimate of the number of trees that can be expected to die within the near future (i.e., snag recruits). The number of recently dead trees provides an estimate of the mortality rate of trees and the current health conditions of the stand. However, wildlife trees in decay class 3 may have died one to several years ago, depending on tree species. Hence, the proportions of these trees do not represent *annual* tree mortality rates.

4.2 Densities and Characteristics of Wildlife Trees

The densities of wildlife trees by species, diameter, height and decay class are presented in Table 2. A total of 110, 148, and 138 live defective, or dead wildlife trees (decay classes 2-7) per hectare were identified at Busk Creek, Redfish Creek, and Deer Creek, respectively. In general, the species-specific wildlife tree densities are proportional to the overall species composition of the stands, with the exception of lodgepole pine at Deer Creek. Here, a relatively large number of small pine died recently from mountain pine beetle attack (Table 2c).

4.3 Healthy (Class 1) Wildlife Trees

Live healthy trees (decay class 1) were omitted from Table 2 because they are defined by evidence of wildlife use and, as shown in Table 3, their inclusion would have biased the distribution of wildlife trees toward the larger diameter classes. However, these trees are important for wildlife tree management because they represent the most valuable timber. Table 3a illustrates that healthy trees used for foraging by woodpeckers were of significantly larger diameter (except in lodgepole pine) than those showing no evidence of use. This is not an artifact of the way in which foraging sign was measured, as the same results are obtained when only new excavations are considered (Table 3b). Overall, 9% and 5% of all live healthy trees showed evidence of accumulated and new foraging sign, respectively.

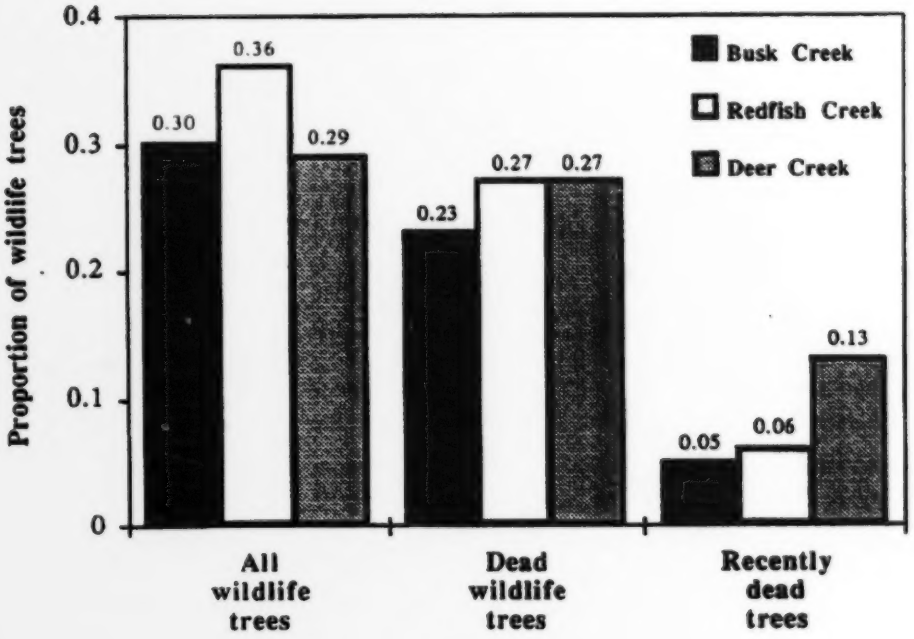

FIGURE 2. Proportion of wildlife trees (all wildlife trees, dead wildlife trees, and recently dead wildlife trees) relative to the total number of trees sampled on study sites (Busk Creek: n=440; Redfish Creek: n=493; Deer Creek: n=1840).

TABLE 2. Density (number/ha) of wildlife trees at Busk Creek (2a), Redfish Creek (2b), and Deer Creek (2c) by species in different diameter, height, and decay classes. Values are means (± SE).

2a. Busk Creek

		Tree species					
Variable	Class	Fd	Pl	Py	Lw	Bg	Ep
dbh[a]	1	33 (7.5)	1 (0.8)	9 (3.7)	0	3 (2.0)	1 (0.8)
	2	16 (3.3)	0	3 (1.4)	0	0	1 (0.8)
	3	8 (3.2)	1 (0.8)	3 (1.8)	3 (1.8)	0	1 (0.8)
	4	4 (2.1)	0	2 (1.7)	0	0	0
	5	14 (3.7)	0	9 (3.3)	1 (0.8)	0	0
Height[b]	1	26 (4.4)	0	10 (4.4)	2 (1.7)	2 (1.2)	0
	2	39 (5.3)	1 (0.8)	6 (2.0)	2 (1.2)	1 (0.8)	2 (1.7)
	3	8 (3.7)	1 (0.8)	7 (2.4)	0	0	2 (1.2)
Decay class[c]	2	16 (3.5)	0	2 (1.2)	0	1 (0.8)	1 (0.8)
	3	22 (6.0)	1 (0.8)	5 (2.2)	0	3 (2.0)	1 (0.8)
	4	9 (3.9)	0	8 (3.2)	0	0	1 (0.8)
	5	12 (4.4)	1 (0.8)	1 (0.8)	1 (0.8)	0	0
	6	8 (2.5)	0	4 (2.1)	1 (0.8)	0	0
	7	5 (1.9)	1 (0.8)	2 (1.2)	0	0	0
Species total		74 (8.1)	2 (1.7)	24 (6.1)	3 (2.0)	3 (2.0)	3 (2.5)
Site total		110 (11.8)					

[a] dbh (cm) class 1: 10-19; class 2: 20-29; class 3: 30-39; class 4: 40-49; class 5: ≥50.

[b] Height (m) class 1: ≤5; class 2: 6-19; class 3: ≥20.

[c] Decay classes are described in Section 3, "Methods".

2b. Redfish Creek

		Tree species						
Variable	Class	Fd	Pl	Pw	Bl	At	Ep	Act
dbh[a]	1	47 (9.7)	1 (0.8)	0	2 (1.2)	1 (0.8)	4 (3.0)	3 (2.5)
	2	28 (5.8)	3 (2.0)	0	0	3 (1.4)	2 (1.7)	0
	3	15 (4.7)	1 (0.8)	1 (0.8)	1 (0.8)	0	1 (0.8)	0
	4	13 (4.1)	0	1 (0.8)	0	0	0	0
	5	18 (4.8)	1 (0.8)	0	0	0	0	0
Height[b]	1	54 (10.6)	0	0	2 (1.2)	2 (1.2)	3 (2.0)	3 (2.5)
	2	53 (8.4)	3 (2.0)	0	1 (0.8)	0	3 (2.0)	0
	3	16 (4.1)	3 (1.4)	2 (1.2)	0	2 (1.2)	0	0
Decay class[c]	2	29 (6.0)	3 (1.8)	2 (1.2)	0	0	3 (1.8)	0
	3	23 (5.7)	1 (0.8)	0	1 (0.8)	2 (1.2)	1 (0.8)	2 (1.7)
	4	20 (5.1)	3 (1.4)	0	0	2 (1.2)	0	1 (0.8)
	5	14 (5.3)	0	0	1 (0.8)	1 (0.8)	0	0
	6	15 (3.7)	0	0	0	0	2 (1.7)	0
	7	18 (5.9)	0	0	0	0	0	0
Species total		123 (16.1)	6 (2.9)	2 (1.2)	3 (1.4)	4 (1.6)	7 (3.8)	3 (1.6)
Site total		148 (18.6)						

[a] dbh (cm) class 1: 10-19; class 2: 20-29; class 3: 30-39; class 4: 40-49; class 5: ≥50.

[b] Height (m) class 1: ≤5; class 2: 6-19; class 3: ≥20.

[c] Decay classes are described in Section 3, "Methods".

2c. Deer Creek

Variable	Class	Tree species						
		Fd	Pl	Py	Lw	Cw	At	Ep
dbh[a]	1	19 (2.9)	41 (8.9)	1 (0.7)	7 (1.9)	0	3 (1.8)	2 (0.8)
	2	13 (2.4)	15 (5.0)	0.3 (0.3)	3 (1.0)	0	0	0
	3	7 (1.4)	3 (1.0)	0	3 (1.0)	0	0	0.3 (0.3)
	4	4 (1.5)	0.3 (0.3)	0	2 (0.9)	0	0	0
	5	7 (2.2)	0	0	1 (0.7)	0.3 (0.3)	0	0
Height[b]	1	17 (3.3)	20 (8.3)	0.3 (0.3)	6 (1.6)	0	0	0.3 (0.3)
	2	23 (3.1)	30 (6.1)	1 (0.7)	6 (1.6)	0	3 (2.1)	1 (0.7)
	3	11 (2.7)	10 (3.6)	0	4 (1.4)	0.3 (0.3)	1 (0.7)	0.3 (0.3)
Decay class[c]	2	3 (1.0)	2 (0.8)	0	0.3 (0.3)	0.3 (0.3)	0	1 (0.5)
	3	18 (3.6)	45 (11.3)	1 (0.7)	9 (2.1)	0	2 (1.1)	0
	4	13 (3.0)	14 (5.3)	0.3 (0.3)	5 (1.4)	0	1 (0.9)	0
	5	6 (1.4)	1 (0.4)	0	2 (0.6)	0	1 (1.2)	0.3 (0.3)
	6	7 (1.9)	0.3 (0.3)	0	0.3 (0.3)	0	1 (0.5)	0
	7	5 (1.5)	0.3 (0.3)	0	0.3 (0.3)	0	0	0.3 (0.3)
Species total		52 (6.1)	62 (12.7)	1 (0.7)	16 (3.2)	0.3 (0.3)	5 (2.6)	2 (0.8)
Site total		138 (14.0)						

[a] dbh (cm) class 1: 10-19; class 2: 20-29; class 3: 30-39; class 4: 40-49; class 5: ≥50.

[b] Height (m) class 1: ≤5; class 2: 6-19; class 3: ≥20.

[c] Decay classes are described in Section 3, "Methods".

TABLE 3. Diameter of healthy (class 1) trees at Deer Creek that were either used or not used for foraging by woodpeckers. Woodpecker use is defined on the basis of old and new foraging sign (3a) or new foraging sign only (3b). Standard errors and sample sizes are given in parentheses. Percent (%) used is calculated as the number of trees used divided by the sum of used and unused trees, multiplied by 100.

3a. Use refers to both old and new foraging sign

Species	Mean dbh (SE, n)		% Used	T-value	P-value
	Used	Not used			
Fd	46 (2.1, 75)	25 (0.5, 732)	9	12.6	< 0.001
Pl	19 (1.1, 16)	17 (0.3, 381)	4	1.1	0.256
Lw	40 (3.1, 23)	19 (0.7, 148)	13	9.3	< 0.001
Py	57 (7.5, 4)	32 (2.5, 14)	22	4.1	0.001
Cw	59 (7.8, 4)	22 (2.1, 42)	9	5.0	< 0.001
At	52 (1.3, 3)	22 (1.2, 49)	6	6.1	< 0.001
Hw	40 (-, 1)	16 (3.0, 5)	17	-	-
Ep	17 (-, 1)	17 (0.7, 86)	1	-	-

3b. Use refers to new foraging sign only

Species	Mean dbh (SE, n)		% Used	T-value	P-value
	Used	Not used			
Fd	46 (3.0, 41)	25 (0.5, 732)	5	6.6	< 0.001
Pl	19 (1.2, 12)	17 (0.3, 381)	3	1.5	0.172
Lw	42 (4.1, 13)	19 (0.7, 148)	8	5.5	< 0.001
Py	57 (7.5, 4)	32 (2.5, 14)	22	4.1	0.001

4.4 Proportions and Characteristics of Woodpecker Foraging Trees

The proportions of all wildlife trees with woodpecker foraging sign are summarized in Table 4. Trees of large diameter (>30 cm dbh) in more advanced decay stages (class 4 to 7) appear to be preferred for foraging. This trend is also apparent when only new foraging sign is considered and it is consistent across species, with the exception of lodgepole pine at Deer Creek. In that case, a large number of small diameter, recently dead lodgepole pine were used in addition to larger, more decayed trees. This result is due to the foraging activity of species such as the Three-toed and Black-backed Woodpeckers which were frequently observed extracting mountain pine beetle larvae from beneath the bark of infected lodgepole pine in the study area. No obvious preference was found with respect to the height of feeding trees, presumably because most foraging takes place on the lower boles of trees.

Table 4d summarizes foraging sign by tree species and site. For those conifer species for which adequate sample sizes could be obtained (Douglas-fir, lodgepole pine, ponderosa pine, and western larch), more than 50% of all wildlife trees showed evidence of foraging use. Western larch showed the highest percentage of use (83%), based mainly on the Deer Creek data. For all species and sites combined, the total usage of wildlife trees was 58%. Factoring in the use of class 1 wildlife trees (9% for all species combined, Table 3) indicates that approximately two-thirds (67%) of all wildlife trees are used as foraging substrate by woodpeckers. Since wildlife trees accounted for about one-third of all trees within the study sites (Figure 2), we conclude that approximately one-quarter of all trees constitute woodpecker foraging habitat.

A total of 159 direct observations on foraging woodpeckers were obtained at the Deer Creek study site in 1994. The characteristics of the trees used by the different woodpecker species are summarized in Table 5. Red-naped Sapsuckers primarily used small, healthy trees, especially paper birch, which is consistent with their feeding mode of drilling wells into vigorously growing trees to extract sap. The other woodpecker species tended to use medium-sized hard snags in their search for bark and wood-boring insects. Our data further suggest that Three-toed Woodpeckers show preference for lodgepole pine (to feed on mountain pine beetle; see Table 9), and that mature Douglas-fir and western larch are important habitat trees for most woodpecker species.

TABLE 4. Proportions and characteristics of wildlife trees at Busk Creek (4a), Redfish Creek (4b), and Deer Creek (4c) with evidence of woodpecker foraging sign. Values are percentages, with sample sizes in parentheses. Table 4d provides species and site totals.

4a. Busk Creek

Variable	Class	Tree species						
		Fd	Pl	Py	Lw	Bg	Ep	All species
dbh[a]	1	34 (41)	0 (1)	27 (11)	-	0 (4)	0 (1)	29 (58)
	2	47 (19)	-	50 (2)	-	-	0 (1)	45 (22)
	3	50 (8)	100 (1)	67 (3)	33 (3)	-	0 (1)	50 (16)
	4	80 (5)	-	100 (2)	-	-	-	86 (7)
	5	82 (17)	-	73 (11)	100 (1)	-	-	79 (29)
Height[b]	1	68 (31)	-	67 (12)	0 (2)	0 (3)	-	60 (48)
	2	36 (45)	100 (1)	43 (7)	100 (2)	0 (1)	0 (2)	36 (58)
	3	70 (10)	0 (1)	63 (8)	-	-	0 (1)	60 (20)
Decay class[c]	2	11 (19)	-	0 (2)	-	0 (1)	0 (1)	9 (22)
	3	24 (25)	0 (1)	0 (6)	-	0 (3)	0 (1)	17 (36)
	4	50 (10)	-	67 (9)	-	-	0 (1)	55 (20)
	5	93 (14)	-	100 (1)	100 (1)	-	-	94 (16)
	6	100 (10)	-	100 (5)	100 (1)	-	-	100 (16)
	7	83 (6)	100 (1)	50 (2)	-	-	-	78 (9)

[a] dbh (cm) class 1: 10-19; class 2: 20-29; class 3: 30-39; class 4: 40-49; class 5: ≥50.

[b] Height (m) class 1: ≤5; class 2: 6-19; class 3: ≥20.

[c] Decay classes are described in Section 3, "Methods".

4b. Redfish Creek

Variable	Class	Tree species							
		Fd	Pl	Pw	Bl	At	Ep	Act	All species
dbh[a]	1	33 (51)	0 (1)	-	0 (2)	0 (1)	0 (5)	0 (3)	27 (63)
	2	42 (38)	0 (4)	-	-	0 (3)	0 (2)	-	34 (47)
	3	65 (20)	0 (1)	0 (1)	100 (1)	-	0 (1)	-	58 (24)
	4	40 (15)	-	100 (1)	-	-	-	-	44 (16)
	5	76 (21)	0 (1)	-	-	-	-	-	73 (22)
Height[b]	1	65 (63)	-	-	100 (1)	0 (2)	0 (4)	0 (3)	57 (73)
	2	32 (62)	0 (4)	-	0 (2)	-	0 (4)	-	30 (72)
	3	39 (18)	0 (3)	50 (2)	-	0 (2)	-	-	32 (25)
Decay class[c]	2	3 (35)	0 (3)	50 (2)	-	-	0 (3)	-	5 (43)
	3	36 (28)	0 (1)	-	0 (1)	0 (2)	0 (2)	0 (2)	28 (36)
	4	46 (24)	0 (3)	-	-	0 (1)	-	0 (1)	38 (29)
	5	63 (16)	-	-	0 (1)	0 (1)	-	-	56 (18)
	6	88 (16)	-	-	-	-	0 (2)	-	78 (18)
	7	90 (21)	-	-	-	-	-	-	90 (21)

[a] dbh (cm) class 1: 10-19; class 2: 20-29; class 3: 30-39; class 4: 40-49; class 5: ≥50.

[b] Height (m) class 1: ≤5; class 2: 6-19; class 3: ≥20.

[c] Decay classes are described in Section 3, "Methods".

4c. Deer Creek

Variable	Class	Tree species							
		Fd	Pl	Py	Lw	Cw	At	Ep	All species
dbh[a]	1	36 (76)	45(138)	67 (3)	63 (24)	-	54 (13)	25 (4)	44 (258)
	2	91 (43)	87 (52)	100 (1)	100 (9)	-	-	0 (1)	87 (106)
	3	96 (23)	89 (9)	-	100 (11)	-	-	100 (1)	95 (44)
	4	100 (15)	100 (1)	-	100 (7)	-	-	-	100 (23)
	5	96 (24)	-	-	100 (3)	100 (1)	-	-	96 (28)
Height[b]	1	84 (56)	69 (67)	0 (1)	90 (20)	-	-	0 (1)	77 (145)
	2	67 (76)	54 (94)	100 (3)	86 (21)	-	50 (10)	50 (4)	63 (208)
	3	74 (38)	76 (37)	-	73 (15)	100 (1)	33 (3)	0 (1)	73 (95)
Decay class[c]	2	27 (11)	0 (7)		100 (1)	100 (1)	-	33 (3)	26 (23)
	3	59 (59)	58 (148)	100 (3)	81 (31)	-	0 (4)	-	61 (245)
	4	84 (38)	63 (41)	0 (1)	88 (16)	-	100 (2)	50 (2)	75 (100)
	5	79 (19)	100 (2)	-	80 (5)	-	80 (5)	-	81 (31)
	6	95 (21)	100 (1)	-	100 (1)	-	67 (3)	-	92 (26)
	7	88 (17)	100 (1)	-	100 (1)	-	-	0 (1)	85 (20)

[a] dbh (cm) class 1: 10-19; class 2: 20-29; class 3: 30-39; class 4: 40-49; class 5: ≥50.

[b] Height (m) class 1: ≤5; class 2: 6-19; class 3: ≥20.

[c] Decay classes are described in Section 3, "Methods".

4d. Species and site totals

Site	Tree species											
	Fd	Pl	Py	Lw	Cw	Bg	At	Ep	Act	Bl	Pw	All species[a]
Busk Creek	50	50	56	60	-	0	-	0	-	-	-	49
	(88)	(2)	(28)	(3)		(4)		(3)				(128)
Redfish Creek	47	0	-	-	-	-	0	0	0	33	50	41
	(143)	(7)					(4)	(8)	(3)	(3)	(2)	(170)
Deer Creek	72	60	75	84	100	-	53	33	-	-	-	67
	(172)	(199)	(4)	(55)	(1)		(13)	(6)				(450)
All sites[a]	58	58	58	83	100	0	41	12	0	33	50	58
	(403)	(208)	(32)	(58)	(1)	(4)	(17)	(17)	(3)	(3)	(2)	(748)

[a] Weighted average.

4.5 Characteristics of Nest Trees and Surrounding Habitat

A total of 115 active nests of cavity-nesting birds and mammals was located on or near the three study sites from 1992 to 1994. Table 6 summarizes the characteristics of nest trees and cavity height for four recognized groups of cavity nesters: (1) woodpeckers, which are strong excavators, (2) nuthatches and chickadees, which are weak excavators, (3) Brown Creepers, which build hammock-like nests in cavities created by the separating bark of trees, and (4) squirrels, which are secondary cavity nesters in old woodpecker cavities. Selected characteristics of the habitat surrounding the nest trees within 0.04-ha

TABLE 5. Characteristics of trees used for foraging by woodpecker species. Diameter (dbh) and decay classes are expressed as medians (range).

Woodpecker species	Trees (n)	Tree species (%)	dbh (cm)	Decay class
Red-naped Sapsucker	61	Ep=69, Fd=20, Dm=3, Pl=3, Act=3, Hw=2	<20	1 (1-3)
Hairy Woodpecker	36	Fd=44, Pl=22, At=17, Ep=11, Lw=3, Act=3	20–30	3 (1-5)
Three-toed Woodpecker	37	Pl=76, Lw=22, Fd=3	20–30	2.5 (1-6)
Pileated Woodpecker	8	Fd=63, Lw=36	20–30	4 (1-5)
Black-backed Woodpecker	8	Lw=50, Fd=36, Cw=13	40–50	3 (3)
Downy Woodpecker	9	Ep=44, Fd=44, Lw=11	20–30	4 (1-9)

plots are also presented in Table 6. The following general trends in the characteristics of nest trees are suggested by these results:

Tree species: Woodpeckers nested primarily in paper birch and trembling aspen (77%), nuthatches and chickadees preferred Douglas-fir (58%), Brown Creepers nested only in western larch and lodgepole pine, and squirrels bred in both hardwoods and conifers.

Diameter: Woodpeckers nested in trees of 44.5 cm dbh, on average, and selected nest trees measuring 6–7 cm larger in diameter than the nest trees of the other cavity nesters; this is presumably due to their larger size.

Decay stage: Woodpecker nest trees were less decayed than those of the weak excavators and the secondary cavity-nesting squirrels. Brown Creepers also nested in live trees or hard snags, as such trees have the appropriate bark conditions for their specialized nest-building habit.

Cavity height: Cavity excavators built their nests at approximately 15 m height which was more than twice as high as the nests of creepers and squirrels. The location of the nest cavity in relation to the overall tree height was at about the midpoint for woodpeckers and squirrels, close to the top for nuthatches and chickadees, and relatively close to the ground for Brown Creepers.

Nest plot characteristics: The average slope (ca. 20%) and aspect (ca. 217°) of the terrain at nest trees were very similar for all groups. Total stem density, 440–540 stems per hectare (sph), was also similar for the true cavity nesters, but Brown Creepers nested in habitats

TABLE 6. Characteristics of nest cavities, nest trees, and nest plots (0.04 ha) of woodpeckers (6a), nuthatches and chickadees (6b), Brown Creepers (6c), and squirrels (6d). All sites are combined. Species codes are explained in Appendix 1; sph = stems (>10 cm dbh) per hectare.

6a. Woodpeckers[a] (n=30)

Nest tree/cavity characteristics			Nest plot characteristics		
Variable	Mean (SE)	Range	Variable	Mean (SE)	Range
dbh (cm)	44.5 (3.5)	23-104	Slope (%)	20 (3.9)	0-66
Decay stage (1-7)	3.4 (0.3)	1-6	Aspect (degrees)	241	16-318
Tree height (m)	24.8 (1.9)	7-46	sph (all trees)	534 (46)	175-1325
Cavity height (m)	15.7 (1.5)	4-35	sph (live conifers)	196 (51)	0-1325
Cavity height to tree height ratio	0.63 (0.04)	0.32-0.99	sph (live deciduous)	222 (33)	0-650
Tree species	At=12, Ep=11, Lw=4 Fd=2, Py=1		sph (snags)	117 (46)	175-1325

[a] Includes Red-naped Sapsucker, Northern Flicker, and Pileated, Three-toed, Hairy, and Downy Woodpecker.

6b. Nuthatches and Chickadees[a] (n=71)

Nest tree/cavity characteristics			Nest plot characteristics		
Variable	Mean (SE)	Range	Variable	Mean (SE)	Range
dbh (cm)	38.4 (2.3)	10-97	Slope	25 (2.3)	0-70
Decay stage (1-7)	4.8 (0.1)	2-7	Aspect	225	8-342
Tree height (m)	15.1 (1.1)	1-44	sph (all trees)	540 (32)	150-1475
Cavity height (m)	11.8 (0.8)	1-29	sph (live conifers)	286 (27)	0-1250
Cavity height to tree height ratio	0.82 (0.02)	0.29-1.00	sph (live deciduous)	88 (19)	0-625
Tree species	Fd=41, Lw=11, Ep=10 At=6, Py=2, Pl=1		sph (snags)	165 (16)	0-600

[a] Includes Red-breasted Nuthatch, Black-capped Chickadee and Chestnut-backed Chickadee.

almost twice as dense as those of the former (794 sph). Woodpeckers and squirrels had more deciduous trees surrounding their nest trees, whereas nuthatches, chickadees, and Brown Creepers nested in areas where conifers dominated and snags were more abundant.

6c. Brown Creepers (n=8)

Nest tree/cavity characteristics			Nest plot characteristics		
Variable	Mean (SE)	Range	Variable	Mean (SE)	Range
dbh (cm)	37.3 (4.2)	23-56	Slope	21 (5.4)	0-43
Decay stage (1-7)	3.3 (0.4)	1-4	Aspect	189	90-279
Tree height (m)	24.2 (3.7)	8-40	sph (all trees)	794 (108)	400-1275
Cavity height (m)	6.5 (1.5)	0.5-13	sph (live conifers)	453 (103)	25-900
Cavity height to tree height ratio	0.34 (0.1)	0.02-0.80	sph (live deciduous)	144 (77)	0-600
Tree species	Lw=5, Pl=3		sph (snags)	197 (40)	25-350

6d. Squirrels[a] (n=6)

Nest tree/cavity characteristics			Nest plot characteristics		
Variable	Mean (SE)	Range	Variable	Mean (SE)	Range
dbh (cm)	37.5 (6.1)	19-64	Slope	19 (4.2)	5-27
Decay stage (1-7)	4.1 (0.6)	2-6	Aspect	242	104-315
Tree height (m)	14.8 (2.9)	6-26	sph (all trees)	440 (50)	325-600
Cavity height (m)	6.7 (0.9)	3.7-10.1	sph (live conifers)	155 (56)	25-300
Cavity height to tree height ratio	0.55 (0.13)	0.21-0.98	sph (live deciduous)	195 (83)	0-450
Tree species	Ep=3, Fd=1, Pl=1, Lw=1		sph (snags)	105 (46)	0-225

[a] Includes Red Squirrel and Northern Flying Squirrel.

4.6 Distribution of Wildlife Trees

The distribution of active nest trees and trees used for foraging by woodpeckers within different ICHdw site series is given in Table 7. A comparison of this distribution with the availability of site series within the study area (determined on the basis of sampling plots) indicates that:

- the wetter site series 04 and 03 received relatively little use,
- site series 01b was used extensively and somewhat more than expected based on availability, and
- wildlife tree use declined in sites series 01a and 02 with increasingly drier site conditions, respectively.

TABLE 7. Proportional representation of sampling plots and wildlife tree use in ICHdw site series within the Deer Creek landscape unit, Arrow Forest District. Values are percentages and sample sizes (n) for plots and trees are indicated.

	Site series					
	hygric		mesic		xeric	
	04	03	01b	01a	02	n
Sampling plots[a]	0	5	45	36	14	85
Trees with active nests	1.5	1.5	63	28	6	67
Trees with old nest cavities[b]	3	0	67	18	12	33
Trees with woodpecker feeding sign[b]	0.5	2	56	36	5	607

[a] Sampling plots were overlayed on cruise plots and along striplines that is, they were evenly distributed.
[b] Sample is based on the 85 cruise and stripline plots and 67 nest plots.

The number of active nests found within the proposed cutblocks at Deer Creek is given in Table 8. The number of active nests per hectare ranged from 0.12 to 1.17 and the total for all cutblocks combined was 0.70 nests per hectare. The differences between the adjacent blocks 5 and 6 and blocks 7 and 8 are surprising but they may be related to subtle differences in the suitability of trees and surrounding habitat for nesting. Block 7 had the highest incidence of Armillaria root disease (and an abundance of nuthatch nests), whereas block 8 had an extensive patch of large deciduous hardwoods. However, the four cutblocks did not differ markedly with respect to tree species composition, terrain features, and the incidence of insects and diseases. Active nests located in close proximity but outside the cutblock boundaries are not included in Table 8.

TABLE 8. Active nests of cavity-nesting birds and mammals found in 1994 on proposed cutblocks in the ICHdw of the Deer Creek landscape unit, Arrow Forest District.

Cutblock	Size (ha)	No. nests	No. nests/ha
5	18.6	8	0.43
6	8.2	1	0.12
7	17.9	21	1.17
8	8.1	7	0.86
All cutblocks	52.8	37	0.70

4.7 Wildlife Trees and Disturbance Agents

Wildlife trees were not homogeneously distributed throughout the study sites as indicated by the relatively high standard errors associated with the average wildlife tree densities reported in Table 2. The number of wildlife trees per sampling plot ranged from 1 to 11, 1 to 16, and 0 to 33 at Busk Creek, Redfish Creek, and Deer Creek, respectively. This

patchy occurrence of wildlife trees is related to the presence of forest health factors such as insects and diseases.

Assessment of the primary disturbance agents associated with trees on which woodpeckers were directly observed foraging revealed that: Red-naped Sapsucker mainly used healthy trees (61%); Three-toed Woodpeckers foraged on trees infested by mountain pine beetle (76%); Black-backed Woodpeckers preferred mistletoe-infected western larch (63%); and Hairy Woodpeckers used trees infected by Armillaria root disease (49%).

A summary of the tree diseases detected on nest trees at the Deer Creek study site is given in Table 9. A total of 85% of all nest trees showed visible evidence of one or several diseases (the remaining 15% may have had stem rot as well, but because these trees had no visible conks they were assessed as healthy based on our methodology). The majority of nest trees chosen by weak excavators (nuthatches and chickadees) were Armillaria-infected.

TABLE 9. Diseases associated with trees used for nesting by cavity nesters. Values are proportions. Sample sizes (n) are for the total number of trees used.

	Disturbance agents[a]				
	Healthy	ARD	LM	SR	n
Woodpeckers	36	14	14	29	14
Nuthatches/Chickadees	5	57	19	12	42
Brown Creeper	33	17	17	0	6
Squirrels	20	20	0	20	5
All cavity nesters	15	42	16	15	67

[a] Disturbance agents: ARD = Armillaria root disease, LM = larch mistletoe, SR = stem rot inferred from visible conks.

5 DISCUSSION

Wildlife trees within study sites in the ICHdw biogeoclimatic subzone of Kootenay Lake and Arrow Forest Districts accounted for approximately one-third of all trees sampled, and approximately one-quarter of all those sampled trees were dead. Wildlife tree densities ranged from 110 to 148 wildlife trees per hectare. The major tree mortality agents in the ICHdw study sites included Armillaria root disease (at all three sites), as well as mountain pine beetle and larch mistletoe at Deer Creek. The large number of wildlife trees and diverse tree species composition within the ICHdw study sites is responsible for an abundant and diverse fauna of cavity nesters. A total of seven woodpecker species were detected within the Deer Creek area; the maximum woodpecker species diversity reported

for northern temperate forests is eight species (Short and Horne 1990). Up to nine active nests of six different cavity-nesting species were located within a 1-ha area and it appears that the ICHdw subzone (especially the 01b site series) provides important habitat for cavity nesters. Wildlife tree and cavity nester surveys in other subzones are needed to confirm this result. If broader-based surveys support the trends in the relative importance of site series observed here, this information could be used to develop habitat suitability mapping for cavity nesters.

Large mature trees are important foraging substrates for insectivorous cavity nesters. Our results on the preferred use of large decay class 1 wildlife trees are consistent with those of other studies that have investigated foraging preferences of bark-foraging birds (Mannan et al. 1980; Bull 1987; Swallow et al. 1988; Lundquist and Manuwal 1990; Mariani and Manuwal 1990) and may be explained by a number of factors. Trees of large diameter tend to have more deeply furrowed bark (such as Douglas-fir) and these reportedly provide optimal habitat (i.e., temperature and moisture conditions) for overwintering insect larvae and pupae. Furthermore, large diameter trees with more deeply furrowed bark support a greater abundance and diversity of insects than do smaller trees (Jackson 1979; Bull 1987; Mariani and Manuwal 1990), thereby increasing the foraging substrate available to avian predators without increasing their area of search or energetic costs of searching.

The majority of woodpecker feeding trees were dead trees in more advanced stages of decay, and measuring greater than 30 cm dbh. Large decaying Douglas-fir are important for Pileated Woodpeckers as these trees often harbor carpenter ant colonies, the Pileateds' preferred food (Bull et al. 1992). Mountain pine beetle-infested lodgepole pine were the primary foraging substrate for Three-toed Woodpeckers (see also Goggans et al. 1989), and Black-backed Woodpeckers appeared to specialize on mistletoe-killed western larch which had been attacked by flat-headed and round-headed woodboring beetles. Western larch (in the Deer Creek area) showed the highest proportional feeding use, which is likely related to their relatively large size, high degree of mistletoe infection, and frequent attack by the energetically profitable woodborers. Paper birch and trembling aspen showed less foraging use than conifers, although live deciduous hardwoods in our study area are preferred feeding trees for sapsuckers.

Mature trembling aspen and paper birch are among the most important nest trees for woodpeckers (see also Machmer et al. [1995]; Steeger et al. [1995]). These hardwoods are often invaded by the heart rot fungi *Phellinus tremulae* and *Fomes fomentarius*. The rots

soften the inner wood, thereby facilitating cavity excavation, but the trees often retain a hard outer shell for some time which protects the nests from inclement weather and predators. Most nest trees of chickadees and nuthatches were broken-off, bare Douglas-fir trunks with the nest cavity located directly below the breakage point. Many of these trees were killed by Armillaria root disease and subsequently invaded by decay fungi (saprophytes) such as *Fomitopsis pinicola*. These fungi soften the wood to such an extent that weak excavators are capable of chiseling out cavities in them.

Although it is clear that (1) cavity nesters, especially woodpeckers, feed extensively on bark- and wood-boring beetles (Machmer and Steeger 1995) and (2) heart or stem rots play important roles in preparing trees for cavity excavation, the role of Armillaria root disease in creating wildlife tree habitat requires further investigation. Our data suggest that Armillaria may be an important factor in two ways. First, the root disease increases the susceptibility of trees to insect attacks, thereby creating feeding opportunities for cavity nesters. This assumption is corroborated by Tkacz and Schmitz (1986) who provide evidence for an association between an endemic mountain pine beetle population and Armillaria-infected lodgepole pine in Utah. However, while these authors suggest that trees are more susceptible to beetle attack when infected with Armillaria, Unger and Vallentgoed (1990) found the converse relationship in the Flathead River drainage of the Nelson Forest Region, where the incidence of Armillaria increased following mountain pine beetle infestation. It appears therefore, that these two forest health factors are interrelated. The second way that Armillaria may be an important factor is that it predisposes trees to invasion by heart rot and decay fungi, which in turn creates nesting opportunities for cavity nesters. We therefore hypothesize that Armillaria root disease plays an important role in creating wildlife tree habitat, and encourage further studies to test this hypothesis and to investigate the various interactions of forest health factors and their consequences for forest wildlife species.

A total of 0.70 active nests per hectare (37 nests on 52.8 ha) were located within the boundaries of the proposed cutblocks in the ICHdw subzone of the Deer Creek landscape unit (Arrow Forest District). If this result is representative for the ICH biogeoclimatic zone in general, it might be useful for calculating the direct impact of summer logging on populations of cavity nesters. This point is illustrated in the following example.

An estimated 3000 ha are allocated for summer logging in the ICHdw and ICHmw2 subzones of Arrow Forest District in 1995 (Rick Biller, Arrow Forest District, pers.

comm.). Unless surveys are conducted to locate and protect active nests before logging, we can assume (using the figure above) that approximately 2100 active nests will be destroyed during the 1995 summer logging season. Although this estimate should be interpreted cautiously, it does provide an indication of the direct impact of summer logging on cavity nester populations and draws attention to the need for wildlife surveys on cutblocks. Considering that this figure is based on only one year and one biogeoclimatic zone from one of British Columbia's 48 Forest Districts, the urgent need for sound wildlife tree management guidelines is clear. Furthermore, although it is illegal in British Columbia to fell a tree that contains an active nest of any bird (B.C. *Wildlife Act*, Section 35), many get destroyed unintentionally because loggers are generally not trained to detect active nests. We advocate that wildlife and wildlife tree surveys be conducted on cutblocks before harvesting and that active nest trees be protected within "wildlife tree patches" in order to resolve this forest/wildlife management problem. A detailed methodology for establishing wildlife tree patches in operational forests is given in Steeger et al. (1995).

6 MANAGEMENT RECOMMENDATIONS

The following section outlines some considerations and recommendations for the development of an integrated wildlife tree management program in the Nelson Forest Region. This is a starting point and more comprehensive management guidelines will evolve as additional information becomes available.

6.1 Wildlife Trees and Forest Management Planning

- Wildlife tree management is an integral part of the provincial strategy to conserve biodiversity in British Columbia. Wildlife trees are considered in the provincial Forest Practices Code and general guidelines for wildlife tree retention are given in the Forest Practices Code *Biodiversity Guidebook* (B.C. Ministry of Forests 1995).

- Regionally, wildlife tree retention during harvesting and silviculture operations should be implemented by forest managers. Specific objectives should be identified for landscape units, five-year forest development plans, total chance plans, silviculture prescriptions, and logging plans. These objectives should take into account: (1) the guiding principles of the FPC *Biodiversity Guidebook* and *Managing Identified Wildlife Guidebook*, (2) existing Forest Ecosystem Networks within landscape units; (3) existing pest

management plans; and (4) the known or suspected presence of red- and blue-listed species, as well as regionally important wildlife species within operational areas.

- A methodology for establishing wildlife tree patches in operational forests has been developed for the Nelson Forest Region and is currently under review[2]. We recommend that this methodology and its applicability throughout the region be tested. A starting point may be to use this approach in the special and integrated management areas delineated in the West Kootenay-Boundary and East Kootenay Land-Use Plans (Government of British Columbia 1995), and on cutblocks considered for summer logging.

6.2 Stand Level Wildlife Tree Retention

- During harvesting and silviculture operations, wildlife trees may pose a hazard to forest workers. It is therefore recommended that wildlife trees be retained in patches that constitute no-work zones (for details, see B.C. Wildlife Tree Committee 1995). All applicable B.C. Workers' Compensation Board Industrial Health and Safety Regulations must be complied with when snags are retained during forestry operations.

- Wildlife tree patches should contain enough habitat components such that the viability of resident individuals, breeding pairs and, ultimately, local populations can be maintained. Live wildlife trees (decay class 1 and 2) that do not pose a hazard to workers may be left during harvesting without the establishment of no-work zones.

  Wherever they are possible to retain, patches should contain a mixture of the following special habitat components:

  - ◊ actively used nest trees (many nest trees are used repeatedly over several years);
  - ◊ recruitment nest trees such as:

    - * mature deciduous hardwoods greater than 40 cm dbh and 20 m in height, with some sign of heart rot (for woodpeckers);
    - * coniferous snags greater than 30 cm dbh and 15 m in height, with moderate decay (for weak excavators);

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[2]Steeger, C., M.M. Machmer, and P. Field. 1995. Methodology for establishing wildlife tree patches in operational forests of the Nelson Forest Region. Unpubl. report, B.C. Min. For., Nelson Forest Region.

* hard snags with broken tops;
* trees with loose bark (for creepers and bats);
* trees with old woodpecker cavities (for secondary cavity nesters); and
* trees with large natural cavities (for larger species such as marten);

◊ trees containing ant colonies, beetles, or other insects (to meet the feeding requirements of insectivorous species);
◊ recruitment insect host trees such as susceptible lodgepole pine; and
◊ trees with special features such as brooms, cankers, and cracks (all of which are known to provide micro-habitats for wildlife species).

- Although it is difficult to speculate at this time about quantitative habitat requirements of wildlife tree-dependent species, we recommend (based on the current and site-specific abundance and diversity of wildlife species) that approximately 10-20% of each cutblock (especially for clearcutting silviculture systems) be retained as wildlife tree patches. Less retention area may be required if a block shows little evidence of current use or is fairly dense and uniform in structure (in which case, some wildlife tree creation through topping of trees may be appropriate). Conversely, a larger percentage may be required on blocks with an exceptionally high abundance of breeding pairs, or if the habitat requirements of an endangered, threatened, or vulnerable species calls for preservation of larger areas. Even for silviculture systems other than clearcutting (such as seed-tree, shelterwood, and selection systems), wildlife tree patch retention should be applied, as snags cannot be retained during any logging operation unless they are surrounded by appropriate no-work zones.

- In general, locations of wildlife tree patches should be chosen in a way that minimizes habitat fragmentation. This can be accomplished by placing wildlife tree patches in relatively close proximity to each other, or as extensions of other leave patches such as riparian zones, seed tree patches, inoperable or unmerchantable forested areas, and sensitive areas.

- Details on content, shape, size, and location of wildlife tree patches should be determined by local teams of resource specialists involved in the design and planning of a particular timber harvest. These details should be based on:

◊ pre-harvest wildlife tree inventories (e.g., of tree species, density, type, distribution, and use by wildlife species);

◊ total resource plan objectives (including water quality, wildlife, timber production, and visuals);

◊ forest health conditions (such as those of insects, disease, fire, wind, and snow); and

◊ conditions for a continued supply of wildlife trees.

6.3 Forest Health Considerations

- Considering that forest insects and diseases maintain wildlife tree habitat, and that cavity-nesting birds and other wildlife tree users are effective natural control agents (of the same forest pests that create their habitat), research efforts should focus on the balancing forces of these ecological correlates. Any imbalances will likely reduce forest health.

- As part of a wildlife tree management program, forest insects (pests) and their habitat should be maintained at endemic levels. Stands with high beetle hazard, for example, can be treated with pheromone baiting (or selectively logged) to reduce the probability of epidemic outbreaks[3]. However, attempts to eradicate beetle populations by removing all potential host trees from a stand should be avoided, as this would likely remove the habitat of woodpeckers and other insectivorous wildlife tree users.

- As part of a wildlife tree management program, a low level, sporadic but persistent incidence of Armillaria root disease should be considered as an essential forest ecosystem component worth maintaining. If wildlife tree patches contain Armillaria root rot centres, then a more desirable management approach might be to plant less susceptible species such as ponderosa pine, western larch (Morrison 1981), and paper birch around the periphery of root rot centres.

[3]Phero Tech Inc. 1993. Options for the management of mountain pine beetle on the south shore of the West Arm of Kootenay Lake. Unpubl. report, B.C. Min. For., Nelson, B.C.

APPENDIX 1. Scientific names and codes of plants and animals mentioned in the text. Bird and mammal species are based on Cannings and Harcombe (1990) and plants on Braumandl and Curran (1992).

English name	Scientific name	Species codes
Bird species		
Red-breasted Nuthatch	*Sitta canadensis*	RBNU
Chestnut-backed Chickadee	*Parus rufescens*	CBCH
Black-capped Chickadee	*Parus atricapillus*	BCCH
Red-naped Sapsucker	*Sphyrapicus nuchalis*	RNSA
Three-toed Woodpecker	*Picoides tridactylus*	TTWO
Black-backed Woodpecker	*Picoides arcticus*	BBWO
Hairy Woodpecker	*Picoides villosus*	HAWO
Downy Woodpecker	*Picoides pubescens*	DOWO
Pileated Woodpecker	*Dryocopus pileatus*	PIWO
Northern Flicker	*Colaptes auratus*	NOFL
Brown Creeper	*Certhia americana*	BRCR
Mammal species		
Northern Flying Squirrel	*Glaucomys sabrinus*	GLSA
Red Squirrel	*Tamiasciurus hudsonicus*	TAHU
Tree species		
Douglas-fir	*Pseudotsuga menziesii*	Fd
Grand fir	*Abies grandis*	Bg
Subalpine fir	*Abies lasiocarpa*	Bl
Western larch	*Larix occidentalis*	Lw
Lodgepole pine	*Pinus contorta*	Pl
Ponderosa pine	*Pinus ponderosa*	Py
Western white pine	*Pinus monticola*	Pw
Trembling aspen	*Populus tremuloides*	At
Paper birch	*Betula papyrifera*	Ep
Black cottonwood	*Populus trichocarpa*	Act
Western redcedar	*Thuja plicata*	Cw
Western hemlock	*Tsuga heterophylla*	Hw

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